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THE JAPANESE BEETLE IN PENNSYLVANIA

By C. H. HADLEY,

(In cooperation with New Jersey Department of Agriculture and United States Department of Agriculture.)

F. P. WILLITS, Secretary of Agriculture

C. H. HADLEY, Director, Bureau of Plant Industry

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HARRISBURG, PA.
1924

PENNSYLVANIA DEPARTMENT OF AGRICULTURE

Administrative Organization

FRANK P. WILLITS, *Secretary* JOHN M. McKEE, *Deputy Secretary*

This Department is essentially a service agency created by legislative enactment to deal with administrative, regulatory, investigational, and educational problems which can best be solved through public rather than individual action. The organization provides for coordination and cooperation with the Pennsylvania State College and the U. S. Department of Agriculture. The Department operates through the following bureaus:

ANIMAL INDUSTRY: T. E. MUNCE, *Director and State Veterinarian.*

Prevents and eradicates transmissible diseases of animals and poultry, including tuberculosis of animals, in cooperation with Federal Government.

Demonstrates to veterinarians control methods for transmissible animal diseases;

Supervises vaccination for and the prevention of hog cholera, anthrax, black leg and hemorrhagic septicemia;

Protects public from unwholesome meats through ante and post mortem examinations of animals at slaughtering establishments;

Inspects, licenses and furnishes information as to breeding, soundness and conformation of stallions and jacks standing for public service;

Enforces law requiring licensing of dogs and providing for protection of livestock and people from attacks of uncontrolled dogs;

Maintains laboratory for diagnostic research and experimental projects.

PLANT INDUSTRY: C. H. HADLEY, *Director.*

Tests agricultural seeds for purity and germination, and enforces State Seed Law;

Inspects orchards, parks, farms, and plant imports for injurious insects and plant diseases;

Enforces laws governing apicultural practices, disease control and housing;

Places and enforces quarantines and carries on eradication campaigns against insect pests and plant diseases;

Inspects and certifies potatoes for seed purposes;

Makes field tests of insecticides, fungicides and weed killers;

Inspects and licenses Pennsylvania nurseries, and licenses all dealers in nursery stock; makes investigations for the control of injurious insects and plant diseases;

Maintains collections of insects, plant diseases, plants, and seeds, and identifies specimens.

FOODS AND CHEMISTRY: JAMES FOUST, *Director.*

Accomplishes its purpose of protecting Pennsylvania homes against harmful foodstuffs by sampling, analyzing, and bringing prosecution under the laws relating to foods and non-alcoholic drinks, including milk, cream, butter, ice-cream, eggs, sausage, fresh meats, soft drinks, fruit syrups, vinegar and kindred food products;

Regulates and issues licenses for the manufacture and sale of oleomargarine;

Licenses and regulates egg-opening plants and cold storage warehouses, maintaining regular inspection and enforcing twelve-month storage limit;

Inspects milk plants and creameries and regulates weighing, testing, buying and selling of milk and cream on a butterfat basis;

Protects honest manufacturers, importers, selling agents and ultimate users of feeding stuffs, fertilizers, lime products, linseed oil, paint, putty, turpentine, insecticides and fungicides, by means of annual registrations followed by inspections, analyses, prosecutions and the publication of the analyses of these products;

Analyzes special samples for residents of the State at the rate of $1.00 a sample for feeding stuffs, lime products and linseed oils.

MARKETS: PORTER R. TAYLOR, *Director.*

Investigates and assists in the marketing of farm products; at present chiefly grain and hay, fruits and vegetables, poultry and eggs, and tobacco;

Compiles and distributes daily market information as to supplies, shipments and prices;

Advises growers on transportation of agricultural products;

Assists cooperative associations and public markets;

Establishes standard grades of farm products and maintains inspection.

STATISTICS: LEWIS H. WIBLE, *Director.*

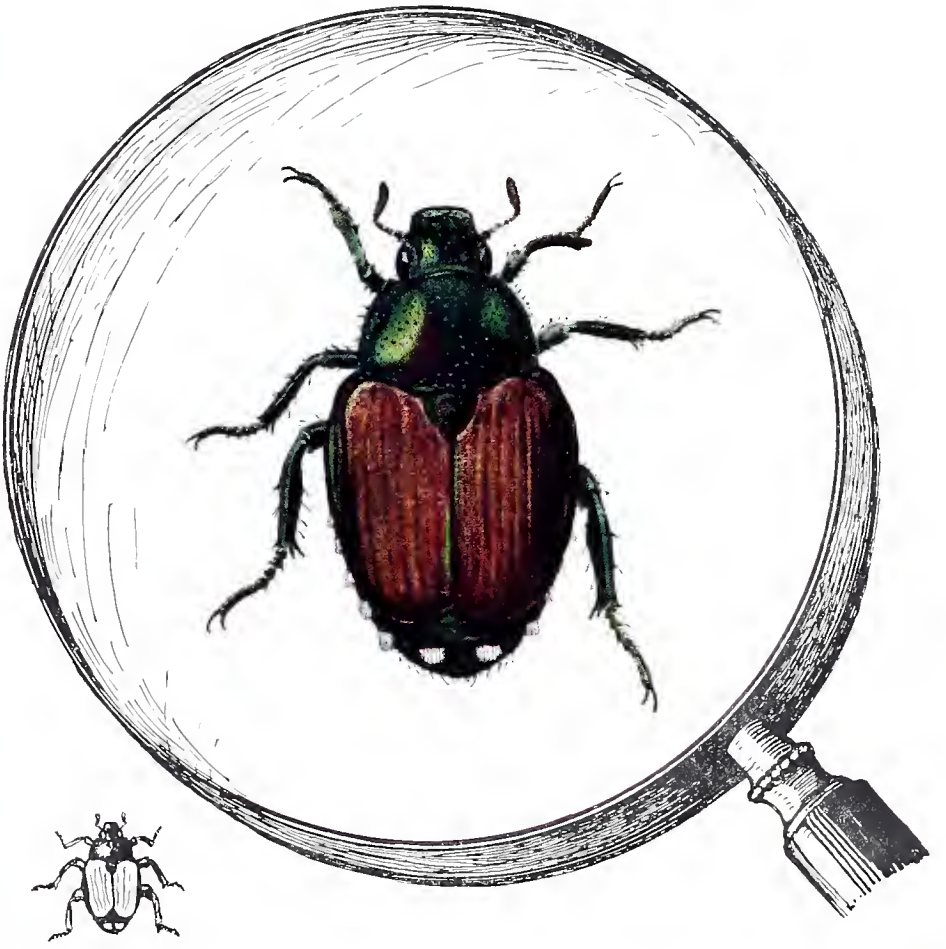
Assembles and disseminates essential statistics and facts pertaining to the agriculture of the State, from monthly reports rendered by hundreds of volunteer crop correspondents, information which assists the producer in his sales and interests all industries which deal with agricultural products;

Cooperates with U. S. Bureau of Agricultural Economics in joint crop and livestock reporting and publishes annual and monthly summaries of the data;

Compiles dates of county and local fairs and assembles data pertaining to their success and results during each year.

PENNSYLVANIA DEPARTMENT OF AGRICULTURE
BUREAU OF PLANT INDUSTRY
HARRISBURG

THE JAPANESE BEETLE



THE JAPANESE BEETLE *(Popillia japonica* Newm.)

The colored illustration shows the beetle magnified about 4½ times; the smaller figure shows its natural size. The insect is about the size of a potato beetle, but slightly longer. The head and thorax are shining bronze green in color, with the wing covers tan or brownish, tinged with green on the edges. Along the sides of the abdomen are white spots, with two very distinct white spots at the tip of the abdomen, below the wing covers.

It is a destructive pest of orchards, fruits, shade and ornamental trees which has been accidentally introduced into this country from Japan. It is as yet found only in parts of Pennsylvania, New Jersey and Delaware surrounding Philadelphia.

(See over for further information)

Life History of the Japanese Beetle.

The beetles (see colored illustration on other side) appear about the 10th to 15th of June, and are most abundant and active from the last of June to the last of August. They feed on early ripening fruit (especially apples, peaches, and plums), the blossoms and foliage of practically all fruit trees, small fruits, shade trees and ornamental shrubs, as well as some vegetables and many common weeds of field and roadside.

The female beetles lay their eggs in the ground in summer, from 30 to 60 eggs during the season. The eggs hatch into larvae or grubs, which stay in the ground and feed on roots of grasses and other vegetation. They are especially injurious in fall and spring to grass in lawns and golf courses, as well as pastures and grasslands. During winter the grubs remain dormant in the ground, commencing feeding again in early spring. In late spring they change to pupae, which develop into the parent beetles.

The Pennsylvania Department of Agriculture, in cooperation with the states of New Jersey and Delaware and the Federal Government, is endeavoring to prevent the further spread of the pest (by enforcement of quarantine restrictions), to devise methods for controlling the pest (by life history and insecticide investigations), and to introduce natural enemies (parasites) from Japan to fight it.

LEARN TO RECOGNIZE THE JAPANESE BEETLE, WATCH OUT FOR IT, and report (with specimens) any beetle resembling the Japanese beetle (see colored picture over) to the nearest office listed below:

Bureau of Plant Industry, Harrisburg, Pa.
Japanese Beetle Office, Holmesburg, Pa.
Department of Agriculture, Trenton, N. J.
Japanese Beetle Laboratory, Riverton, N. J.
U. S. Bureau of Entomology, Washington, D. C.
or the County Agent at the Agricultural Extension Office.

(See over for further information)

THE JAPANESE BEETLE[1] IN PENNSYLVANIA

By C. H. HADLEY[2]

INTRODUCTION

It is well known to entomologists that many if not most of our more serious insect pests are not native to this country, but have been introduced through accidental means into the country from their native homes. The Japanese beetle is not an exception to this, since it is an insect native to Japan, and was introduced into the United States at Burlington County, New Jersey, probably prior to 1916. The exact date of its introduction into this country can not be definitely determined, but it was not discovered and recognized as an introduced species until 1916, when it was found by inspectors of the New Jersey Department of Agriculture during the course of their annual summer inspection of nurseries.[3]

As to the mode of introduction, again this point can not be definitely determined, but it seems probable that the insect came over in the grub stage in soil about the roots of certain perennial plants, such as iris and azalea.

Since the time of its finding in 1916, the insect has not only extended the area which it covers up to a total of approximately 2400 square miles, but the increase in density of the insect in the infested territory has been truly remarkable. Along with this increase in territory which it covers, and the increase in density, has come the natural and corresponding increase in feeding range, so that now the insect has reached the stage where it presents every probability of becoming a pest of very great importance. In the case of the Japanese beetle we have an outstanding example of the ability of an insect to flourish in a new environment, when such new environment is especially well adapted to its needs.

OCCURRENCE AND SPREAD IN THE UNITED STATES

To date (spring 1924), the Japanese beetle is not known to occur in the United States outside of the infested portions of New Jersey

[1] *Popillia japonica* Newm., order Coleoptera, family Scarabaeidae.

[2] The Japanese Beetle Project is a cooperative one between the State of Pennsylvania, the State of New Jersey, the State of Delaware, and the Federal Government. The data presented in this Circular are drawn in part from Circular 46 of New Jersey Department of Agriculture, by the same author, and this bulletin is intended to bring up-to-date and summarize in a popular way the information available relating to the Japanese beetle.

[3] Weiss, Harry B.—Information for Nurserymen, N. J. Dept. Agric. Circ. 14, 1918, pp. 3-4. Dickerson, Edgar L., and Weiss, Harry B.—Canadian Entomologist, vol. L, No. 7 (July, 1918), pp. 217-221.

and Pennsylvania, covering some 2442 square miles, 698 miles of which are in Pennsylvania, and 1744 in New Jersey.

While the insect was first discovered in 1916 in New Jersey, it was not found across the line in Pennsylvania until the summer of 1920. During this summer, insects were found in some numbers along the shore of the Delaware River at Torresdale; since that year, however, the spread in Pennsylvania has been relatively uniform from year to year, averaging from five to fifteen miles outward in an air line, from the original center of infestation. At the present time the infestation covers all of Philadelphia County, and parts of Bucks, Montgomery, Chester and Delaware Counties in Pennsylvania, and in New Jersey parts of Salem, Gloucester, Atlantic, Camden, Burlington, Ocean and Mercer Counties.

MEANS OF SPREAD

The beetle is a strong flier and is capable of dispersing itself over considerable distances. The relative spread from year to year, which

Fig. 1. Showing beetles feeding on corn silk, and also how the beetles crawl to the husk, in this way being carried long distances, as the corn is shipped from the infested farm or market.

may be considered as representing the natural average spread under present conditions, is relatively from five to ten miles per year. It

is questionable whether this natural spread from year to year can be lessened to any particular extent through artificial control means, at least not without the expenditure of funds far beyond a practical amount. From the standpoint of the country at large, however, danger of spread over wide areas is not because of the average yearly natural spread but because of the fact that the insect may be accidently distributed over wide areas through artificial means. For example, infested nursery stock might easily carry a sufficient number of individuals of the insect in the larval stage for long distances, to points in states quite remote from the present infested area, and in this manner establish a new infestation within a single season; whereas, a new infestation at such a remote distance from the present infested area would not occur through the natural flight of the insect for possibly a great many years. The insect might also be carried in the adult stage on certain types of farm products, especially sweet corn (fig. 1), cabbage, lettuce or similar plants offering satisfactory hiding places for the insect. The passage of vehicles of one sort or another through the infested territory during the period of beetle flight is still another means by which the insect may be carried for comparatively long distances, and, in fact, instances have been noted where one or more individual beetles have been discovered on or in automobiles passing through the infested territory. There are, of course, other ways by which the insect may be distributed to a greater or lesser extent, the chances of new infestations resulting from other ways than those mentioned, however, being comparatively slight as compared with those previously mentioned.

The rural conditions throughout a great part of the present infested area are favorable to the natural spread of the beetle. The net-work of roads, fence-lines and creeks, all containing a more or less heavy growth of favorite host plants, such as smartweed, grape, five-leaf ivy, elder and sassafras, coupled with the natural ability of the insect to fly readily, all practically insure a fairly steady natural spread of the insect.

FOOD HABITS OF THE BEETLE

The Japanese beetle is most conspicious and injurious in the adult stage by reason of its injury to foliage and early ripening fruit. It is practically omnivorous, feeding on the foliage of weeds of many kinds, small fruits such as grape and blackberry, fruit trees such as apple (fig. 2) and sweet cherry, ornamental shrubs, particularly althea and rose, flower garden flowers of all kinds, field crops such as clover blossoms, soybeans and corn, and shade and timber trees including linden, birch, oak, elm, horse chestnut and willow.

The feeding is characteristic and compares with the eating done by native leaf-chafers. Plants are not defoliated as by certain related beetles, such as the brown May beetle, but the foliage is skeletonized and when severely eaten the leaves turn brown and drop. In the case of flowers the petals are eaten and the blossoms

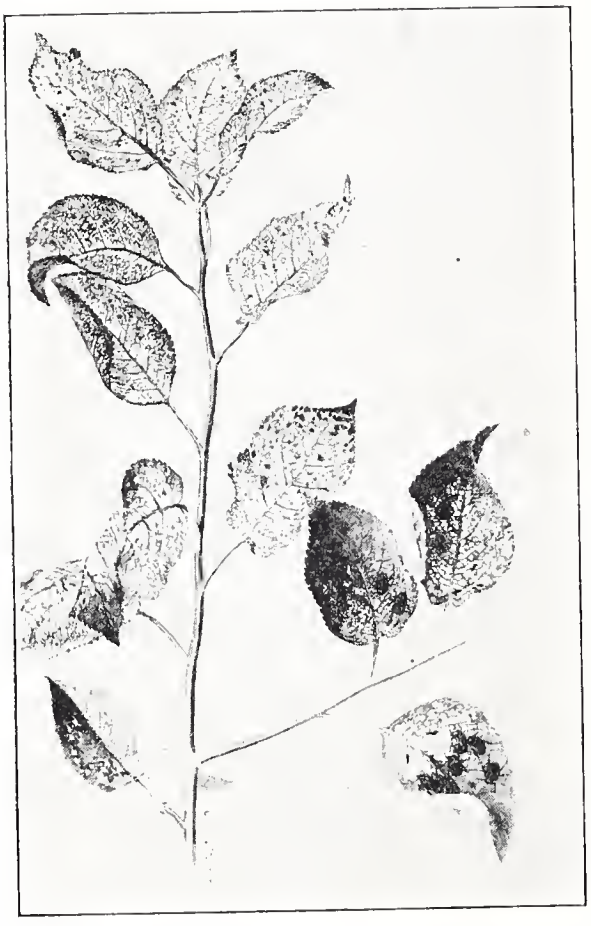


Fig. 2. Injury to apple foliage, showing how the beetles skeletonize the leaves.

riddled as by the rose beetle or chafer; in fact, the work of the Japanese beetle in flowers and foliage closely resembles that of the chafer, except that it is usually more severe, many more kinds of plants are attacked, and the feeding extends over a longer period.

As a pest of early ripening fruit, the Japanese beetle is of primary importance. It attacks particularly the fruit of early ripening varieties of apples, (fig. 3) such as Williams Early Red, Star, Transparent and similar varieties; peaches (fig. 4), highly colored and particularly early ripening varieties such as Greensboro, Rochester and Redbird; early plums, and to a less extent sour cherries are also subject to attack by the beetle, especially when the beetles are numerous in the orchard.

Something over 200 different species of plants are known to be attacked to a varying degree by the Japanese beetle, and in this list

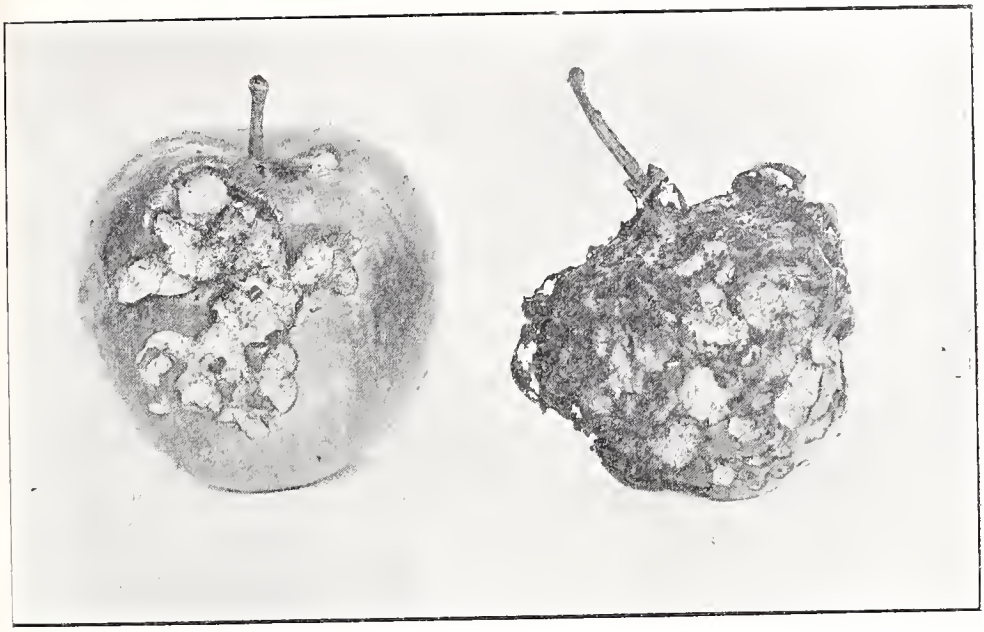


Fig. 3. Apples which have been eaten by the beetles, showing how such fruit is completely ruined for commercial purposes (Courtesy N. J. Dept. of Agr.).

Fig. 4. Showing beetles feeding in clusters on early peaches. This is a characteristic injury to fruit and is very noticeable in heavily infested districts.

are included practically all kinds of economic and non-economic plants growing throughout the infested territory. The most important of the plants attacked are listed below.

ECONOMIC PLANTS

Small Fruits

*Grape, cult. (*Vitis* sp.).
*Raspberry, cult. (*Rubus* sp.).
*Blackberry, cult. (*Rubus* sp.).

Orchard Fruits

*Apple *(Pyrus malus)*. Foliage and fruit (Figs. 2 and 3).
*Cherry, sweet (*Prunus* sp.) and sour.
Plum *(Prunus domestica)*.
Peach *(Amygdalus persica)* (Fig. 4).
Quince *(Cydonia oblonga)*.

Truck Crops

Asparagus *(Asparagus officinalis)*. Foliage and flowers.
Sweet potato *(Ipomœa batatas)*.
Lima bean *(Phaseolus lunatus)*.
String bean *(Phaseolus* sp.).

Field Crops

*Corn *(Zea mays.)*. Foliage, silk, pollen, and ear.
*Soybean *(Glycine soja)*.[1]
*Red Clover *(Trifolium pratense)*. Foliage and flowers.
Alsike clover *(Trifolium hybridum)*. Foliage and flowers.
Alfalfa *(Medicago sativa)*.

Ornamental Shrubs and Vines

*Virginia creeper *(Ampelopsis quinquefolia)*.
*Rose (*Rosa* spp.).
*Althea *(Althæa officinalis)*. Foliage and flowers.[2]
*Japanese rose *(Kerria japonica)*.
Japanese flowering cherry *(Prunus serrulata)*.

Flowering Garden Plants and Miscellaneous

*Hollyhock *(Althæa rosea)*. Foliage and flowers.
Ferns *(Adiantum and Polystichum)*.
Canna *(Canna sp.)*. Foliage and flowers.[2]

Shade and Timber Trees

*Elm, American *(Ulmus americana)*.
*Oaks (white oak group).
*Willow *(Salix* spp.).
*Horse chestnut *(Æsculus hippocastanum)*.

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*Plants thus starred (*) are vigorously attacked. In all cases the foliage is eaten unless otherwise indicated.

[1]Reported as the principal economic food plant in Japan. This crop is not grown commercially within the infested area, but in cages the beetles feed on the foliage of soybean with apparent relish.

[2]Yellow flowers are apparently preferred to the darker shades.

NON-ECONOMIC PLANTS

Weeds

*Smartweed *(Polygonum pennsylvanicum)*. Foliage and flowers.
*Indian or velvet-leaf mallow *(Abutilon abutilon)*.
*Evening primrose *(Enothera biennis)*. Foliage and flowers.
*Sensitive fern *(Onoclea sensibilis)*.
*Mercury weed *(Acalypha virginica)*.
Wild Rose *(Rosa* sp.).
Milkweed *(Asclepias syriaca)*.
Daisy *(Chrysanthemum leucanthemum)*. Flowers only.

Shrubs and Trees

*Sassafras *(Sassafras sassafras)*.
*Wild fox grape *(Vitis labrusca)*.
*Wild summer grape *(Vitis æstivalis)*.
*Elder or elderberry *(Sambucus canadensis)*.
Wild cherry *(Prunus serotina)*.
Alder *(Alnus rugosa)*.

FOOD HABITS OF THE GRUB

During the earlier years of the occurrence of the Japanese beetle in this country, it was not thought that the grub of this insect was likely to become of particular economic importance. The experience of the last few years, however, since the insect has become so abundant in the heavier infested sections, shows beyond any question that the grub of the Japanese beetle is a very serious pest of grass fields, lawns and golf courses.[1]

LIFE HISTORY AND HABITS

The total life cycle (fig. 5) of this insect is one year, most of which time is spent in the soil as an egg, grub or pupa. Having passed the winter in the soil, 1½ to 12 inches below the surface,[2] the half-to nearly full-grown grub comes up close to the surface in late March or early April and resumes feeding. The older grubs complete their growth by early June, when each prepares an earthen cell, 1½ to 3 inches below the surface, in which it transforms to the pupa and about two weeks later to the adult beetle. Previous to pupating

*Plants thus starred (*) are vigorously attacked. In all cases the foliage is eaten unless otherwise indicated.

[1]Leach, B. R., and Johnson, J. P.—Bulletin of the Green Section of the U. S. Golf Assoc., vol. 3, No. 10 (Oct. 22, 1923), pp. 262-268.

Leach, B. R.—Bulletin of the Green Section of the U. S. Golf Assoc., vol. 4, No. 4 (Apr. 16, 1924), pp. 97-101.

[2]During the winter the grubs are 1½ to 12 inches below the surface, the average from many examinations being 5 inches. Successful hibernation is largely in the 3rd (last) instar, although not infrequently also in the 2nd instar.

the grub is in the prepupal or dormant stage for a period of a week or ten days, and after transforming to adult it usually remains in the cell another ten days to two weeks before coming out of the ground. Like the related leaf chafers, this insect pupates within the larval skin, the skin splitting along the back almost the entire length.

The early beetles issue the last of June, and the maximum period of emergence is during the middle part of July. The life of the individual beetle varies considerably, averaging from one to ten weeks. Beetles, however, occur over a period of about four months, although they are most abundant during a period of two to two and one-half months.

After issuing, the beetles feed for several days to a week before mating. Mating and egg-laying are continued at irregular intervals, the eggs being laid by preference in uncultivated places such as grass fields or grassy and weedy areas along roadways, in moist but not swampy ground, and in soil containing humus, each beetle laying an average of 30 to 60 eggs. The young grubs, which hatch from the eggs some two weeks later, feed on decaying matter in the soil and on living plant roots, and late in the fall they form earthen cells, in which they pass the winter.

The beetles are omnivorous, resistant to unfavorable conditions, strong fliers, and very active during warm, clear days. While they may remain above ground on plants during the night, they usually feed only during the day; they are sluggish in cool or damp weather, but exceedingly active on warm, sunshiny days, and fly quickly at the least disturbance, seldom going far into thickets except on the outside foliage. They choose grassy or weedy ground, unshaded by thickets or trees, in which to lay their eggs, and prefer moist, loamy soil to dry, sandy soil or swampy areas.

The complete life round of the insect in shown diagrammatically in figure 5.

THE INSECT DESCRIBED

The Japanese beetle (colored plate)[1] is a beautiful insect about the size of a potato beetle, but more elongate. The head and thorax are shining bronze green and the elytra or wing covers are brownish, tinged with green at the edges. On the sides and at the tip of the abdomen, usually not concealed by the wing covers, are conspicuous white spots, which distinguish this species from all others of the same size and habits occuring in Pennsylvania.

[1]The colored plate shows the adult Japanese beetle in its true coloration, enlarged about 4½ times. The cuts from which the illustration is made are loaned by the..... Department of Agriculture.

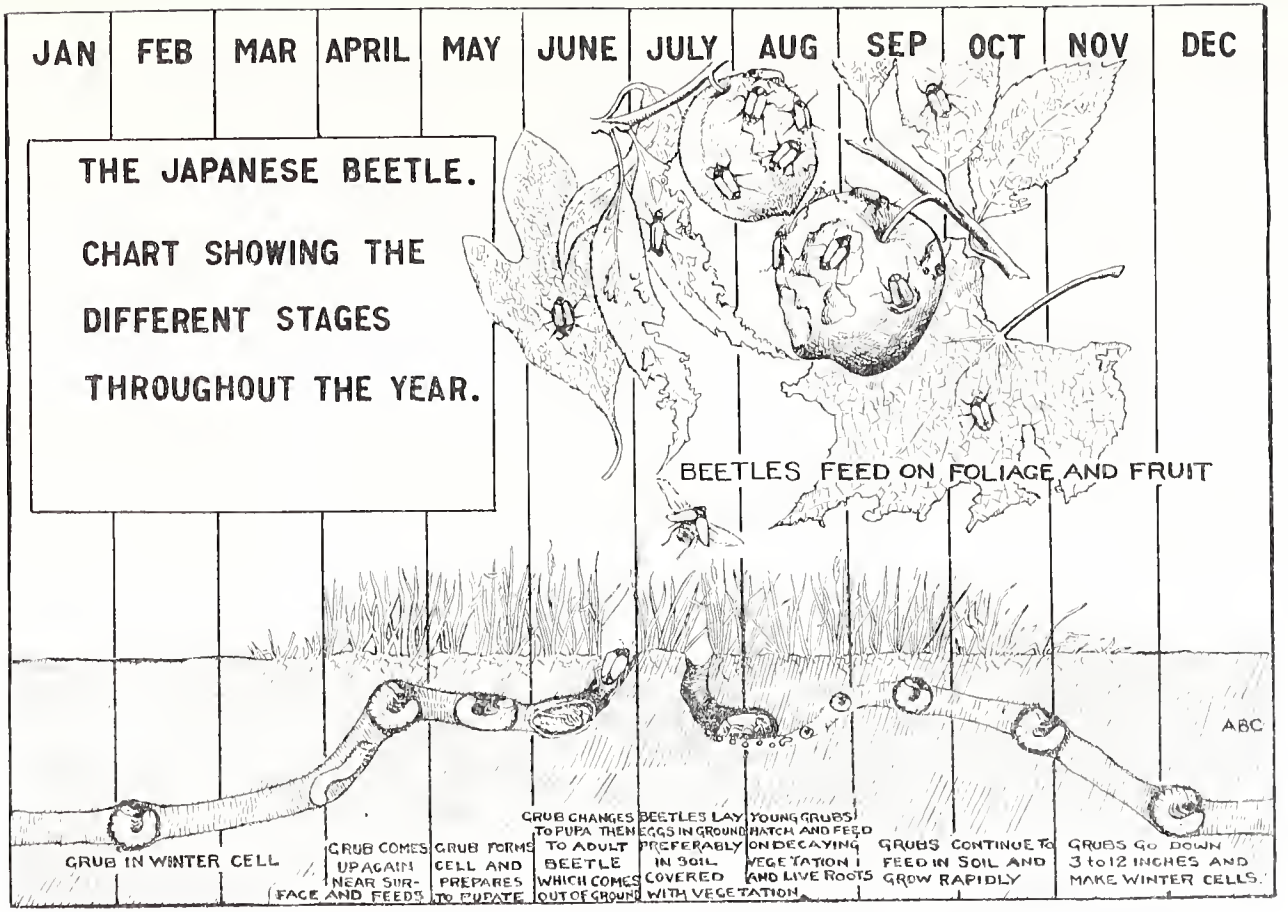

Fig. 5. Diagramatic chart of the life cycle of the Japanese beetle as it occurs in Pennsylvania.

The eggs are laid separately, but usually several are laid near together in the soil, though not in distinct cells. They are milky white and elliptical oval, measuring about 1/24 by 1/16 inches (1 by 1½ mm.) when first laid, later swelling to nearly spherical.

The grubs vary from tiny individuals recently hatched to nearly one inch when full grown.[1] They are white, with a more or less conspicuous bluish or blackish cast, which is especially prominent at the anal end, with a tan colored head. The characteristically curled grubs (fig. 6) closely resemble our native white grub of the field, but are smaller than mature grubs of the latter, and may be seperate as indicated in another paragraph. The pupa, which is the intermediate and dormant stage between the grub and beetle, is of pale tan color, and the appearance is well illustrated in the accompanying figure. (Fig. 6.)

Fig. 6. The grub, or larva, enlarged. The larval stage of the Japanese beetle is similar to, but smaller than, our common white grub, grub-worm or manure grub. (Courtesy of N. J. Dept. Agric.)

BEETLES LIKELY TO BE MISTAKEN

There occur in the eastern United States several kinds of beetles, some of which are closely related to the Japanese beetle, which have been repeatedly mistaken for it. Two common leaf chafers (*Strigoderma arboricola* and *Anomola lucicola*) are very closely related to

[1]Like most other scarabaeid grubs, Popillia has three instars in the grub stage, i. e., it molts twice before changing to pupa. The head widths are rather uniform, averaging about 1.2 mm. in the first; 1.9 mm. in the second, and 3.1 mm. in the third instar.

the Japanese beetle and have been repeatedly confused with it. Both feed on the foliage of grape and riddle it, as does the Japanese beetle, and they are about the same size or slightly smaller than the latter, but lack the conspicuous greenish head and thorax and the greenish abdomen with white spots as described above. The rose beetle has occasionally been confused with the Japanese beetle, but it may be readily distinguished by its more elongate form, small size, and absence of green on the body. The southern green June beetle (*Cotinis nitida*) is sometimes mistaken for the beetle under discussion, but it is much larger, being at least three times as large, and while it is distinctly greenish in color it is velvety green instead of a shiny green, and lacks the white abdominal markings. Another species which has been confused is one of the flower beetles technically known as *Euphoria fulgida*, which is shining green and bears white spots on the margin of the abdomen, but differs from the Japanese beetle by being about twice as large and lacking the contrast in color between the thorax and wing covers. Still another beetle which has been confused is a shining green species known as the milkweed leaf beetle (*Chrysochus auratus*) which is distinguished by the absence of white spots on the abdomen and the lack of contrast between the thorax and wing covers.

GRUBS LIKELY TO BE MISTAKEN

There are many white grubs which have the same general appearance as the grub of the Japanese beetle, a number of which live under the same conditions. Those most likely to be mistaken are grubs of the brown May beetles (*Lachnosterna* spp.), of certain leaf chafers (*Anomola* spp.), of the rose beetle or chafer (*Macrodactylus subspinosus*) and of another common May beetle-like species (*Cyclocephala* spp.). *Cyclocephala* grubs are distinguished by a total absence of rows of spines on the under side of the last abdominal segment; May beetle grubs by conspicuous rows of spines and by the angular anal slit, and leaf chafer and rose beetle grubs by the angular anal slit in comparison with the transverse of the Japanese beetle grub.

THE PROBLEM OF CONTROL

The problem of control of the Japanese beetle is one of several phases. Actual extermination of the insect might possibly have been practicable at one time (although lack of knowledge of the problem and sufficient funds made extermination in the early years impossible), but complete extermination of the insect is no longer within the realm of possibility, because of the size of the area now infested, and the very many practical and insurmountable difficulties in the

way of complete extermination. Practically speaking, the control problem now resolves itself into efforts to prevent the spread of the pest over long distances, to find artificial control measures which are practical from the standpoint of the individual concerned, and to introduce from Japan and other foreign countries natural enemies of the insect, which are likely to be effective in holding down the pest to within reasonable bounds under the conditions existing in this country.

Since the time when the Japanese beetle was first discovered and control work undertaken, the project as a whole has been a cooperative one between the United States Department of Agriculture and the States directly interested. At present, the responsibility for the policy governing the work as a whole lies with a committee representing the cooperating agencies, viz., the States of Pennsylvania and New Jersey, and the United States Department of Agriculture, together with the entomologist in charge of the Japanese beetle project. This arrangement insures full cooperation in the work, and the utilization to the very best advantage of the funds provided for the work, which funds come from the cooperating states and the United States Government.

PREVENTION OF SPREAD

The natural spread of the insect from the early years of its presence in this country has averaged from ten to fifteen miles per year outward in an air line. This natural spread will undoubtedly continue at a more or less normal rate, possibly becoming greater in proportion to the density of infestation and the area covered, and can not be prevented. The normal natural spread of any insect has never been prevented by human agencies on a large scale, so far as the writer knows, once an insect has become firmly established in a favorable environment.

On the other hand, the artificial spread of an insect over long distances beyond the area of natural spread, can be prevented, or at least limited, through strict quarantine enforcement. For the last five years, a quarantine has been in force which restricts the movement of farm, garden and orchard products, as well as nursery stock and other plant products, and including soil; both states concerned and the Federal Government have promulgated quarantine orders and regulations, the state orders supplementing the Federal orders. Copies of these regulations may be obtained from any of the Departments concerned, and in Pennsylvania may be secured by addressing the Bureau of Plant Industry of the State Department of Agriculture, at Harrisburg, Pa.

PERFECTING PRACTICAL CONTROL MEASURES

Extensive studies have been carried on in an effort to discover or devise a practical means of fighting the insect. A great many materials and combination of materials have been tried out both in the laboratory and in a practical way in the field, in an effort to discover an insecticide which would be satisfactory as a killing agent of the insect, and at the same time be within a reasonable cost. It has been very thoroughly shown during the course of the work, that the many factors involved render the proposition of practical control of the insect on a large scale quite difficult. It may, however, be said that a practical and satisfactory means of fighting the insect is actually in sight, although it must also be remembered that the utilization of any satisfactory and practical means of control for the insect involves an additional cost to the grower.

Better success has attended the efforts to find means of destroying the grubs in the soil, especially with reference to treatment of infested lawns, golf courses and grass lands (See foot note,[1] page 9).

INTRODUCTION OF NATURAL ENEMIES

In its native home, Japan, the insect is known locally as the bean beetle, and occurs more or less generally throughout the islands constituting the Japanese Empire; it is, however, abundant and injurious only locally at times, and at such times may cause some injury to such economic plants as soy beans, grape, rose, peanut, prune, apple and pear. Under conditions obtaining in its native home the control of the insect is not a matter of very great importance. For several seasons now American entomologists have been maintained in Japan and nearby countries, studying the problem of the Japanese beetle there, and determining the agencies responsible for the apparent unimportance of the insect in its native home. It now seems quite probable that the freedom of that country from serious injury by the insect, is due to a very great extent to the action of natural enemies of the insect, to the soil, cultural and climatic conditions peculiar to the country, and more probably to a combination of these several agencies.

As a result of the investigations carried on over there, several shipments of parasites have already been sent to this country for study, reproduction and liberation in the infested territory, and it is confidently expected that further shipments will also be continued. While it is as yet too early to state definitely the final results of this work, it now appears that at least two of the species of parasites sent over thus far have become established, at least in limited numbers, in the heavily infested territory, and that other species sent over may likewise in the future become established. It is believed that the final solution of the Japanese beetle problem in this

country is the establishment of natural enemies in sufficient number and variety to hold the insect under reasonable control, but that this desirable end will not be secured except by continuous and vigorous efforts in the introduction and dissemination of these natural enemies, and that such efforts must be continued for a period of years to insure satisfactory results.

In this connection it may be stated positively that such species as have already been introduced, and as may be introduced in the future, are in no case dangerous to the production of crops in this country. Parasites which will be effective against the Japanese beetle can not possibly become pests of vegetation, since they are not vegetation-feeding types.

Among the other natural enemies of the insect, birds are without question of considerable importance. It has been found that a number of our commoner birds do feed upon this insect, notably the purple grackle or crow-blackbird (*Quiscalus quiscalus*), and the starling (*Sturnus vulgaris*). Most of our other commoner species feed more or less upon this insect, and all are of considerable value in the aggregate.

RECOMMENDATIONS FOR CONTROL

The following recommendations[1] for control are based on investigations covering a period of several years, and represent the most satisfactory methods as yet evolved. It is hoped and generally believed that better methods of handling the problem will be developed, but meanwhile the adoption and following of the recommendations given herewith should insure a reasonable degree of protection from the attack of the insect.

EARLY AND LATE APPLES

Materials Used.—Three pounds of powdered arsenate of lead, 2 pounds of flour, 50 gallons of water. Mix the arsenate of lead and flour dry, then add water to make a paste, dilute and strain into spray tank; this prevents lumps forming.

When to Spray.—In order to protect the foliage and fruit from the attacks of the beetles it is necessary to have the spray applied before infestation takes place. To obtain the desired results, the application of the sprays must be completed not later than June 25. Growers should arrange their spraying operations to have their beetle sprays applied by that date. In case of heavy rains washing much of the spray off the plants, it may be necessary to repeat the application ten days or two weeks later after the first spraying in order to maintain a coat.

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[1]These recommendations have been prepared by the Bureau of Entomology of the United States Department of Agriculture.

How to Spray.—A thorough job of spraying must be done to protect your plants and control the beetles. This means that the foliage and fruit must be completely covered by a film of the spray. Unless this is done your time and money will be wasted, since the beetles will attack the unsprayed portions of the plants and may concentrate on the fruit.

Precaution.—Early apples sprayed shortly before time of harvest have on them a deposit of the spray. This can be removed readily by having the pickers wear cotton gloves and wipe the fruit when it is harvested, or by sending it over a grader or other machine equipped with rotary brushes or some other cleaning device.

Note.—This spray should be applied not later than June 25th. While this treatment will serve for both codling moth and Japanese beetle it includes no fungicide, and where diseases liable to be present require a fungicide this treatment should be considered as an additional and separate application.

LATE PEACHES

Materials Used.—One and one-half pounds of powdered arsenate of lead; 2 pounds of flour; to 50 gallons of water. Mix the arsenate of lead and flour dry, then add water to make a paste, dilute and strain into spray tank; this prevents lumps forming.

When to Spray.—Peaches must not be sprayed with arsenate of lead closer than one month to the time of harvest. In most cases the Japanese beetle spray can be applied on late varieties providing the spraying is completed by June 25. This will give sufficient time for the arsenate of lead residue to be washed from fruit by rains before marketing.

How to Spray.—As in the case of apples, a thorough job of spraying must be done in order to protect the foliage and fruit from the attacks of the beetles. In order to cover the foliage with the spray properly, it is necessary to use at least 1½ gallons of spray mixture to each tree 10 to 12 years old.

Note.—This should be considered as a separate and additional treatment and not as a substitute for some member of the regular spray schedule, because it carries no fungicide.

EARLY PEACHES

Our present knowledge of spraying early peach trees to protect them from the attack of the Japanese beetle is insufficient to permit us to make any recommendations. Some growers during the season of 1923 apparently obtained some success by making early applications of arsenate of lead in the form of a spray instead of a dust. It is believed that a certain amount of lead arsenate will accumulate where the spray is used, and that this accumulation will

have a tendency to prevent the attacks of the beetle later in the season. It is also of some value to spray all trees surrounding the early peach orchard with the heavy application of arsenate of lead such as is recommended for apples, providing those trees are of such nature that they can withstand the application of a large amount of lead. Such a spray will have a tendency to prevent the beetle from congregating in that particular area.

Where the peach trees are heavily infested with the Japanese beetle it may be of some value to spread large canvas or burlap sheets beneath the trees, and jar the beetles from the trees on to the canvas. This can be done early in the morning, that is, before 7 a. m. At this time it is cool and the beetles are more or less inactive and large quantities can be gathered in this way. As the beetles are gathered they can be poured into tubs from the canvas sheets and later destroyed by spraying with kerosene oil and burned or buried. Young, non-bearing peach trees can be sprayed with 1½ pounds of arsenate of lead as recommended for late peaches.

CHERRIES

Materials Used.—Three pounds powdered lead arsenate, two pounds flour, 50 gallons of water. Mix the arsenate of lead and flour dry, then add water to make a paste, dilute and strain into spray tank; this prevents lumps forming.

When to Spray.—Cherry orchards, as a rule, cannot be sprayed with these materials before the crop is harvested. As the cherries are picked the trees should be sprayed. If the beetles are causing very serious injury before the fruit is harvested some protection can be obtained with a spray consisting of 1½ pounds of powdered lead arsenate, 2 pounds of flour, to 50 gallons of water. It is advisable to have the sprays applied by June 25.

How to Spray.—With cherries, as with other fruit trees, it is necessary to do a very thorough job of spraying. The leaves should be coated on both sides with the spray and care should be taken that all the foliage is covered.

GRAPES

Materials Used.—The spray schedule recommended for grapes under Pennsylvania conditions calls for an application of Bordeaux mixture (4-5-50 formula) with 2 to 3 pounds of arsenate of lead (powder) to 50 gallons, applied 10 days after the blossoms fall. For control of Japanese beetle, the same mixture should be used but 3 pounds of powdered lead arsenate must be used to each 50 gallons of Bordeaux and the application should be completed by June 25. Beetles may cause some injury during July or early August, but the attacks will be largely confined to new foliage on the growing shoots.

How to Spray.—Considerable care must be taken in spraying grapes that the foliage is thoroughly covered, since the beetles feed on either side of the leaves and will select any unsprayed portion for their feeding in case a thorough job of spraying is not done. Rods are preferred for this work in order to avoid driving spray.

Note.—Many varieties of grapes, such as Ives, are often seriously burned by heavy applications of Bordeaux. In such cases it is suggested that the spray for Japanese beetle be composed of lead arsenate 3 pounds (powder) and flour 2 pounds, to 50 gallons of water.